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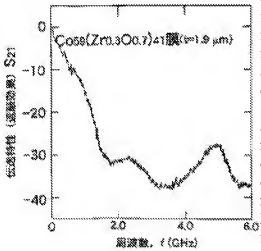
(54) ELECTROMAGNETIC WAVE ABSORBING FILM

(57)Abstract:



PROBLEM TO BE SOLVED: To provide a electromagnetic wave absorbing film which is formed of nano-granular soft magnetic film that is large in electric resistivity, saturation magnetization, and anisotropic magnetic field, and has a large absorbing characteristic of electromagnetic wave in the GHz band.
SOLUTION: This electromagnetic wave absorbing film is formed of nano- granular soft magnetic film, which is represented by a general expression, M100-XIX (M is highly densely distributed ferromagnetic fine grains that are made of either of Co and Ni or more than two kinds of elements and have a particle size of 10 nm or less, and I is a grain boundary substance made of insulator such as an oxide, nitride, or fluoride, etc., surrounding the ferromagnetic fine grains of M, and an atomic ratio X of I is $10<X<50$), and which has a saturation magnetization of 6 kG or higher, anisotropic magnetic field of 30 Oe or more, and electric resistivity of 150 μΩcm or more and has a value of the imaginary part of the complex permeability of 30 or more in the GHz band.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application]This invention relates to the electromagnetic-wave-absorbing film in which the big electromagnetic-wave-absorbing effect is shown in a high frequency band of 1 GHz or more.

[0002]

[Description of the Prior Art]The apparatus in a highly informative society in recent years with a miniaturization. . which high frequency-ization of clock frequency is following at an increasing tempo . in which a typical thing is a personal computer and the clock frequency of the central processing unit is exceeding 1 GHz -- in addition to this -- communication equipment -- a cellular phone (0.9, 1.5, 1.9 GHz). An electronic toll collection system [in / to . pan with which satellite broadcasting (11.7-12.0 GHz), wireless LAN (2.45, 5.0, 19.0 GHz), etc. are carried out or examined / an intelligent transport system (ITS)] (ETC) (5.8 GHz), . it is expected to be that a rear-end collision prevention radar (7.6 GHz) etc. are used, and the high speed in a GHz band and use of a high integration semiconductor integrated element will increase increasingly from now on -- in these semiconductor devices and electronic circuits, Recently, it is a serious technical factor which EMI (electromagnetic wave disorder), such as spurious radiation, is pointed out briskly, and has been a big problem, and checks a miniaturization and highly-efficient-izing of apparatus. EMC (environmental electromagnetism engineering) is thought as important as that synthetic measure, and research of this field is beginning to prosper.

[0003]Although what was necessary was to cover electromagnetic shielding whose drive frequencies of apparatus are several kilohertz - several MHz by soft magnetic materials for every equipment, and just to have covered, if it becomes several 10 - 100 MHz of numbers, it is necessary to shield for every circuit block. And since the wavelength of electromagnetic waves becomes almost comparable as each device or the scale of wiring in the electronic device more than still higher GHz, with the conventional way and material of EMC, correspondence is becoming impossible. In order to cover noise radio waves from the detailed portion in a high frequency band, a new method (micro EMC) and the material for it are required.

[0004]These days, the method of using the magnetic loss of a magnetic body attracts attention as an absorber of the electromagnetic waves in a high frequency band. Although the mechanism of action of the spurious radiation attenuation using the magnetic loss of the magnetic body changes with physical relationship of a noise source and magnetic loss material, etc., When a magnetic body is in the nearest to a noise transmission line, by giving an equivalent resistance component to a transmission line shows that the high frequency current is controlled. Depending on the size of the imaginary part (mu") of a magnetic loss clause or complex magnetic permeability, the size of an equivalent resistance component is proportional to the size of mu" mostly here, when the area of a magnetic body is constant. However, since the imaginary part of the amplitude permeability more than GHz was as small as around 10 or less than it, each conventional material needed to set thickness of the shielding material to 1 mm or more, in order to acquire sufficient shielding effect.

[0005]
[Problem to be solved by the invention]In order micro processing is difficult for such a thick material, and a shield part to heat dissipation is difficult and to be accompanied also by self-generation of heat of a shielding material, A screen is simultaneously wanted to be producible in the making process of . and the element for which the film which applying to the field of micro EMC is a magnetic body very thin in order to obtain very difficult ., therefore noise attenuation of the request as an object for micro EMC, and has fairly big mu" is needed.
[0006]An object of this invention is to provide the electromagnetic-wave-absorbing film which was made in view of the above-mentioned point, and consists of a nano granular soft magnetism film which the imaginary part of amplitude permeability shows a big value in a high frequency band of 1 GHz or more.
[0007]
[Means for solving problem]As a result of trying hard wholeheartedly in view of the above-mentioned situation, in the nano granular soft magnetism film which contains a little Ceramics Sub-Division in a grain boundary, this invention persons find out that the film which shows electromagnetic-wave-absorbing effect with thickness sufficient also in mum size by a large microwave (GHz) zone is obtained, and result in this invention.
[0008]The place by which it is characterized [of this invention] is as follows. The 1st invention is expressed with general formula $M_{100-X}I_X$, and M is the ferromagnetic particles which have the particle diameter of 10 nm or less which consists of any one sort or two sorts or more of elements of Fe, Co, and nickel, It is distributed with high density, and I is a grain boundary substance which consists of any one sort or two sorts or more of insulating materials surrounding the ferromagnetic particles which consist of M of an oxide, a nitride, or fluoride, and the atomic ratio X of the I concerned is $10< X<50$, It is related with an electromagnetic-wave-absorbing film, wherein it has 6 or more kG of saturation magnetization, 30 or more Oe of anisotropy fields, and 150 or more microomegacm of electrical specific resistance and the size of the imaginary part of the complex magnetic permeability in a GHz band consists of a nano granular soft magnetism film which is 30 or more.
[0009]The 2nd invention relates to the electromagnetic-wave-absorbing film of the 1st invention, wherein the atomic ratio X of I consists of a nano granular soft magnetism film whose size of the imaginary part of the complex magnetic permeability in a GHz band it is $20< X<40$, and is 50 or more.
[0010]As for the 3rd invention, I of aluminum-N, aluminum-O, Zr-O, Hf-O, RE-O (RE: rare earth element), Mg-F, and any one-sort ** of Ca-F is two or more sorts of insulating materials, And the size of the imaginary part of the complex magnetic permeability in a GHz band is related with the electromagnetic-wave-absorbing film of the 1st or 2 invention consisting of a nano granular soft magnetism film which is 80 or more.
[0011]The 1st, wherein the 4th invention has 8 or more kG of saturation magnetization, 70 or more Oe of anisotropy fields, and a value of 500 or more microomegacm of electrical specific resistance and the size of the imaginary part of the complex magnetic permeability in a GHz band consists of a nano granular soft magnetism film which is 100 or more. Or it is related with the electromagnetic-wave-absorbing film of 3 invention.
[0012]In not less than 100 ** a temperature requirement 400 ** or less, the 5th invention relates to the electromagnetic-wave-absorbing film of the 1st thru/or 4 invention

consisting of a nano granular soft magnetism film heat-treated in the static magnetic field or the revolving magnetic field so that an anisotropy field may be set to 30 or more Oe.
[0013]The 6th invention relates to the electromagnetic-wave-absorbing film of the 1st thru/or 5 invention consisting of a produced nano granular soft magnetism film by a physical film formation method or the chemical forming-membranes methods, such as sputtering vacuum deposition.
[0014]The 7th invention relates to an electromagnetic-wave-absorbing film given in any 1 clause of the Claims 1-6 for which M is characterized by one-sort ** of Pd and Pt consisting of a nano granular soft magnetism film whose size of the imaginary part of the complex magnetic permeability in a GHz band is 80 or more in the composition ratio of the two-sort sum total including 35% or less.
[0015]In the multilayer film in which the 8th invention made the thin film which becomes any 1 clause of Claims 1-7 from the nano granular soft magnetism film, the insulating material, nonmagnetic substance, or ferromagnetic material of a description laminate by turns, It is related with an electromagnetic-wave-absorbing film, wherein the size of the imaginary part of the complex magnetic permeability in a GHz band is 80 or more.
[0016]The 9th invention relates to the electromagnetic-wave-absorbing film of the 1st thru/or 8 invention, wherein all the thickness consists of nano granular 0.1-micrometer or more a soft magnetism film which is 5 micrometers or less.
[0017]
[Function]
[0018]In order to obtain the substance in which the big electromagnetic-wave-absorbing effect is shown in a specific frequency band, the material which the imaginary part (mu") of amplitude permeability shows a big value in the frequency band is required (Hitoshi Yoshida, a mug NETIKKUSU study group data and 00-1-7, MS-6-7). Namely, in order to obtain a magnetic material with the electromagnetic-wave-absorbing characteristic excellent in the GHz band. The material in which big mu" is shown is needed, and in a GHz band The big saturation magnetic flux density (Bs) into the material, An anisotropy field (Hk) and electrical specific resistance (rho). . Having is called for. (Hitoshi Hosono, Journal of the Maganetics Society of Japan, 12, 295 (1988)) The nano granular soft magnetism film (M:ferromagnetism metal, I: grain boundary substance which consists of insulating materials) of this invention expressed with . general formula $M_{100-X}I_X$ Big Bs of 6 or more kG, Hk of 30 or more Oe. And since it has rho of 150 or more microomegacm, the electromagnetic-wave-absorbing characteristic excellent in the target GHz band is shown. however, since it will become a superparamagnetism film if X will be not less than 50%, big mu" is not obtained . -- at less than 10%, since it becomes perpendicular magnetic anisotropy films while membranous rho becomes extremely small, since mu" becomes small or less with 30, it is not preferred again.
[0019]If not only an oxide but heat of formation is a large substance, a nitride or fluoride will also necessarily be available for I which forms a grain boundary. Since a film will turn into perpendicular magnetic anisotropy films with big coercive force (Hc) if the particle diameter of a nano granular magnetic film is set to not less than 10 nm, big mu" is not realized.
[0020]Since resonant frequency is set to 500 MHz or less by Bs<6kG of a nano granular soft magnetism film in Hk<30Oe, even if rho is large, the peak of mu" will not amount to

1 GHz. Since an eddy current loss becomes large in rho<150microomegacm even if Bs and Hk are large, the peak of mu" becomes small.
[0021]on the other hand -- obtaining -- having -- a film -- 100 -- ** -- more than -- a static magnetic field -- or -- a revolving magnetic field -- inside -- heat-treating -- if -- almost -- being arbitrary -- a size -- an anisotropy field -- a size -- being controllable -- and -- a film -- inside -- distortion -- it can remove -- a sake -- having excelled -- high frequency -- mu -- " -- the characteristic -- being shown -- a film -- it can obtain . However, the grain community diffusion from which heat treatment temperature will be not less than 400 ** will take place, granular structure will be destroyed, and various characteristics begin to deteriorate.
[0022]A nano granular soft magnetism film is usually produced with physical film formation methods, such as sputtering vacuum deposition. However, although considerably limited in presentation, it is producible also by the chemical forming-membranes methods, such as plating. With the thin film which consists of dissimilar material, such as an insulating material, and the multilayer film laminated by turns, soft magnetism-ization promotes a nano granular soft magnetism film by magnetostatic combination between magnetic layers, and the range of selection of a presentation of a magnetic film spreads. Since an eddy current loss also becomes still smaller, the range which shows big mu" is further extended to a high frequency band.
[0023]If 35% or less of Pd and Pt are added by composition ratio to the ferromagnetic metal (M) of a nano granular soft magnetism film, the anisotropy field which controls the frequency characteristic of amplitude permeability will become large, and the composition range which shows soft magnetism will contribute to high frequency-ization of clock frequency while expanding it.
[0024]When thickness is set to 0.1 micrometer or less, an absorption effect becomes extremely small and it becomes impossible to expect a shielding effect. On the other hand, since the eddy current loss is large and the frequency which shows the maximum of mu" will become below GHz even if theoretical resonant frequency is over GHz if set to not less than 5 micrometers, it is not desirable. In order for thickness to obtain a not less than 5-micrometer film, membrane formation takes most time, it is economically disadvantageous, and a membrane surface generates heat and the concern to reform is during membrane formation.
[0025]
[Working example](Embodiment-1) $Co_{82}Zr_{18}$ (atomic %) target using RF magnetron sputtering equipment by the reactive sputtering method in the inside of mixed gas ($Ar+O_2$) atmosphere. The $Co_{59}(Zr_{0.3}O_{0.7})_{41}$ thin film was produced on the conditions shown below.
[0026]
Sputtering gas pressure $5x10^{-3}$Torr supplied power 200W substrate temperature 25 ** Substrate Corning#7059 (0.5 mm in thickness)
Thickness 1.0-2.0 micrometers Oxygen flow rate ratio 0.0 to 1.0% Applied magnetic field 100Oe (permanent magnet of a couple)
[0027]The direct-current magnetic properties of the sample obtained were measured with the sample oscillatory type magnetometer. 1 of a result
例を図１に示す．図中の２つのデータは，成膜時の印加磁界に平行（//），また

** -- vertical -- (**) -- it is the result of magnetizing and measuring. The coercive force of the perpendicularly it has big influence on high frequency magnetic properties is as small as the number Oe. The sample has Hk from which the direction of an applied magnetic field at the time of membrane formation turns into an easy magnetizing direction, and the size is about 160 Oe(s). Since Bs is over 9kG, the natural resonance frequency (fr) of a theoretical film is set to not less than 3 GHz. Since membranous rho is furthermore over 1,000microomegacm, most eddy current losses resulting from thickness can be disregarded. It is expected that this invention film will show the characteristic outstanding as high frequency soft magnetic materials from the above thing.

[0028]The frequency dependence of the amplitude permeability of the aforementioned this invention film for which it asked to 3 GHz is shown in drawing 2. The real part (mu') of amplitude permeability is a flat mostly to near 1 GHz, by more than it, it increases gradually and at least 3 GHz of a limit of measurement of steep depression peculiar to a resonating point is not observed yet. Since the sharp peak of mu" near fr is not observed yet even if mu" increases with frequency like mu' and it is set to 3 GHz, it turns out that fr is not less than 3 GHz. According to Hitoshi Yoshida (above-mentioned), the absorption feature of electromagnetic waves is in agreement with the product of the thickness of a magnetic body, and mu." It turns out that this invention film which has fr in a not less than 3-GHz frequency band, and mu" at that time shows 100 or more big values from this is the outstanding electromagnetic wave absorber in a GHz band.

[0029]On 75 mm of line length, and a microstrip line with a characteristic impedance of 50 ohms, a magnetic body has been arranged and the transmission characteristic of an obtained $Co_{59}(Zr_{0.3}O_{0.7})_{41}$ film was evaluated (drawing 3). The transmission characteristic S21 corresponds to cover or an absorption effect of material. A transmission characteristic decreases remarkably with an increase in frequency, and is set to -30dB near 1.5 GHz. Then, although an increase in a small portion of S21 considered to be based on resonance near 5 GHz is seen, on the whole, it decreases little by little with frequency. This magnetic film shows the very big electromagnetic-wave-absorbing characteristic from this in large frequency band of about 1 GHz or more reflecting a result of the frequency dependence of amplitude permeability of drawing 2.

[0030](Embodiment-2) A $Co_{58}(Zr_{0.3}O_{0.7})_{42}$ film produced on the same conditions as embodiment-1 and a SiO_2 film were laminated by turns, and a $Co_{58}(Zr_{0.3}O_{0.7})_{42}/SiO_2$ multilayer film was produced. A $Co_{58}(Zr_{0.3}O_{0.7})_{42}$ film is 250 nm, the number of times of lamination is 4 times, and a SiO_2 film of each thickness is 50 nm. The characteristics of a $Co_{58}(Zr_{0.3}O_{0.7})_{42}$ film are Bs=8.4kG, Hk=166Oe, and rho=1630microomegacm. The frequency characteristic of amplitude permeability of this multilayer film is shown in drawing 4. Like drawing 2, to 1 GHz, mu' is a flat mostly, increases after that, and exceeds 100 near 3 GHz of a limit of measurement. Since thickness of each magnetic layer becomes thin by multilayer-film-izing, mu" shows the same frequency characteristic as a result of having calculated an eddy current loss as zero. Although a calculation result of natural resonance frequency in this case (fr) is 4.2 GHz and are few, a frequency characteristic improves rather than monolayer. It can guess having shifted fr of survey from this result to the high frequency side further, and a frequency band of that neighborhood shows a big absorption feature.

[0031](Embodiment-3) Membranes were formed on the same conditions as embodiment-

1 using the multicomponent target which stuck Pd chip (5x5 mm) to $Co_{85}Si_{15}$ alloy target. The direct-current magnetic properties of the obtained $_{64}(Co_{0.8}Pd_{0.3})$ $(Si_{0.2}O_{0.8})$ $_{36}$ film are shown in drawing 5. Although Hc of an easy magnetizing direction is quite large, Hc of the difficult magnetizing direction which contributes to a high frequency characteristic is as small as 2.1Oe. Membranous rho is quite as large as 1200microomegacm. The results which should be observed are a size of Hk, and the form of a magnetization curve. This film has big Hk of Hk=190Oe, and distribution of anisotropy is hardly observed by the magnetization curve. From having bigger Hk than the film of embodiment-1, it is expected that resonant frequency will exist in a still higher GHz band, and this invention film shows a big absorption feature in the frequency band of the neighborhood.

[0032](Embodiment-4) The parts and those various characteristics of a thin film of this invention produced by the aforementioned method are shown in Table 1.

[0033]

[Table 1]

組　　成	Bs(kG)	Hc(Oe)	Hk(Oe)	fr(MHz)	μ"(fr)	ρ(μΩcm)
（本発明）						
Co55(Zr0.3O0.7)41 (t=2.1μm)	9.1	2.3	152	(3,800)	(480)	1460
Co65(Al0.3O0.7)35 (1.8)	10.2	3.0	82	2,400	830	580
Co58(Zr0.3O0.7)42/SiO2 (100/20nm)×20	8.8	0.4	148	(3,600)	(510)	1580
(Co0.8Pd0.2)72(Si0.3O0.7)28 (2.3)	8.2	0.2	260	(4,400)	(440)	1220
(Co0.94Fe0.06)68(Mg0.4Fe0.6)32 (2.0)	9.6	1.2	68	1,800	920	420
(Co0.94Fe0.06)64(Sm0.4O0.6)36 (1.4)	9.2	2.2	98	(3,200)	(790)	860
(Co0.8Ni0.2)62(Zr0.3O0.7)38 (1.8)	9.4	2.0	60	1,400	880	620
(Co0.9Pt0.1)60(Si0.2O0.8)40 (1.7)	8.6	1.2	220	(4,200)	(420)	1,310
Co59(Hf0.3O0.7)41 (1.9)	9.0	2.6	72	2,200	690	870
(Co0.9Fe0.1)70(Al0.2N0.8)30 (2.1)	11.8	1.4	48	1,200	1,040	380
（比較例）						
Co82Nb10Zr8 アモルファス(1.2 μm)	9.0	0.1	20	1,100	890	120
パーマロイ (2)	7.8	0.4	5	4	240	30
センダスト (1.5)	9.4	1.2	—	—	—	78

[0034]Each sample shown in Table 1 is a film of a composition range given in a claim. The number shown by () in front is compared with the high frequency soft magnetism thin film material of . former which is the result of asking by calculation in order that resonant frequency may exceed the frequency limit of an evaluation system, As for this invention film, . [rho / Hk and] which has the feature that it is remarkable and large, as a result any film have resonant frequency in a GHz band, and each mu" in resonant frequency is over 100.

[0035][Comparative example] The same method as Embodiment 1 estimated the transmission characteristic for the compound magnetic sheet (commercial electromagnetic wave absorber) and FUREKI shield (made by TDK) which distributed

ferromagnetic impalpable powder with high density in polymer for comparison (drawing 6). To a big absorption feature being shown from near 1 GHz, the $Co_{59}(Zr_{0.3}O_{0.7})_{41}$ soft magnetism film (thickness is about 2 micrometers) of this invention so that clearly from drawing 6, the absorption feature of a FUREKI shield increases little by little with frequency, although thickness has about 400 micrometers -- near 6 GHz -- the result near 2 GHz of a $Co_{59}(Zr_{0.3}O_{0.7})_{41}$ film -- almost -- about [of the level] -- it amounts to -30dB. Since an absorption feature is expressed with the product of the imaginary part of amplitude permeability, and thickness as stated previously, Although the thickness of a $Co_{59}(Zr_{0.3}O_{0.7})_{41}$ film is 1/200 or less [of the thickness of a FUREKI shield], Since a several times as many absorption feature as a FUREKI shield is shown, it turns out that the $Co_{59}(Zr_{0.3}O_{0.7})_{41}$ film has the shield several 100 times the electromagnetic-wave-absorbing characteristic of FUREKI.

[0036]

[Effect of the Invention]Both the electromagnetic-wave-absorbing films of this invention have Hk, Bs, and large rho, and they consist of a nano granular soft magnetism film in which the electromagnetic-wave-absorbing characteristic excellent in the frequency band is shown in order to show the imaginary part of big amplitude permeability in a GHz band. The size of membranous Hk and Bs is optionally changeable in the remarkable wide range by choosing the alloy composition of a nano granular soft magnetism film. Mean that this can change membranous fr optionally and to eye others. Since the electromagnetic-wave-absorbing film of this invention is a thin film, it is easy to radiate heat for . pan it becomes possible to provide easily the thin film which has the electromagnetic-wave-absorbing characteristic outstanding in the GHz frequency band of various kinds of magnetic devices, It is in the production processes of an electron device about the features, like membrane formation is possible, and the industrial meaning is large as an outstanding electromagnetic-wave-absorbing film in a GHz band.

[Translation done.]

CLAIMS

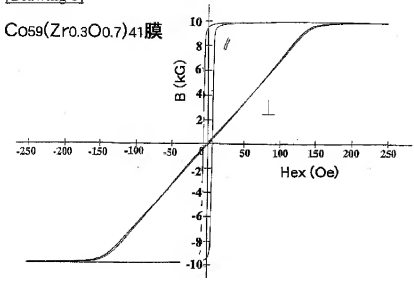
[Claim(s)]

[Claim 1]It is expressed with general formula $M_{100-X}I_X$, and M is the ferromagnetic particles which have the particle diameter of 10 nm or less which consists of any one sort or two sorts or more of elements of Fe, Co, and nickel, It is distributed with high density, and I is a grain boundary substance which consists of any one sort or two sorts or more of insulating materials surrounding ferromagnetic particles which consist of M of an oxide, a nitride, or fluoride, and the atomic ratio X of the I concerned is $10< X<50$, An electromagnetic-wave-absorbing film, wherein it has 6 or more kG of saturation magnetization, 30 or more Oe of anisotropy fields, and 150 or more microomegacm of electrical specific resistance and a size of imaginary part of complex magnetic permeability in a GHz band consists of a nano granular soft magnetism film which is 30 or more.

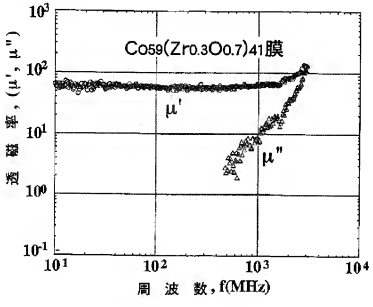
[Claim 2]The electromagnetic-wave-absorbing film according to claim 1 which the atomic ratio X of I is 20< X<40, and is characterized by a size of imaginary part of complex magnetic permeability in a GHz band consisting of a nano granular soft magnetism film which is 50 or more.
[Claim 3]In aluminum-N, aluminum-O, Zr-O, Hf-O, RE-O (RE: rare earth element), Mg-F, and any one-sort ** of Ca-F, I is two or more sorts of insulating materials, And the electromagnetic-wave-absorbing film according to claim 1 or 2, wherein a size of imaginary part of complex magnetic permeability in a GHz band consists of a nano granular soft magnetism film which is 80 or more.
[Claim 4]An electromagnetic-wave-absorbing film given in any 1 clause of Claims 1-3, wherein it has 8 or more kG of saturation magnetization, 70 or more Oe of anisotropy fields, and a value of 500 or more microomegacm of electrical specific resistance and a size of imaginary part of complex magnetic permeability in a GHz band consists of a nano granular soft magnetism film which is 100 or more.
[Claim 5]An electromagnetic-wave-absorbing film given in any 1 clause of Claims 1-4 consisting of a nano granular soft magnetism film heat-treated in a static magnetic field or a revolving magnetic field in not less than 100 ** a temperature requirement 400 ** or less so that an anisotropy field may be set to 30 or more Oe.
[Claim 6]An electromagnetic-wave-absorbing film given in any 1 clause of Claims 1-5 consisting of a produced nano granular soft magnetism film by a physical film formation method or the chemical forming-membranes methods, such as sputtering vacuum deposition.
[Claim 7]An electromagnetic-wave-absorbing film given in any 1 clause of Claims 1-6 to which M is characterized by one-sort ** of Pd and Pt consisting of a nano granular soft magnetism film whose size of imaginary part of complex magnetic permeability in a GHz band is 80 or more by composition ratio of the two-sort sum total, including 35% or less.
[Claim 8]An electromagnetic-wave-absorbing film characterized by a size of imaginary part of complex magnetic permeability in a GHz band being 80 or more in a multilayer film which made a thin film which becomes any 1 clause of Claims 1-7 from a nano granular soft magnetism film, an insulating material, a nonmagnetic substance, or a ferromagnetic material of a description laminate by turns.
[Claim 9]An electromagnetic-wave-absorbing film given in any 1 clause of Claims 1-8, wherein all the thickness consists of nano granular 0.1-micrometer or more a soft magnetism film which is 5 micrometers or less.

DRAWINGS

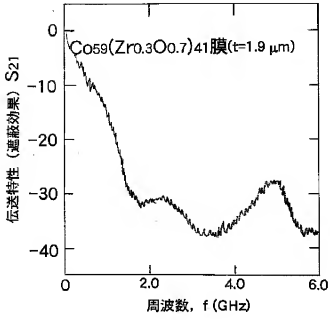
[Drawing 1]



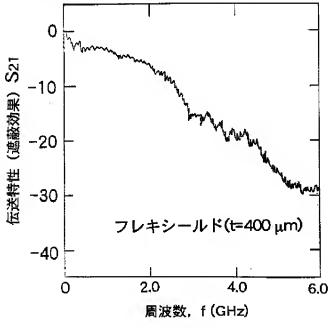
[Drawing 2]



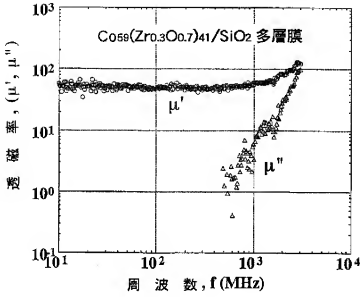
[Drawing 3]



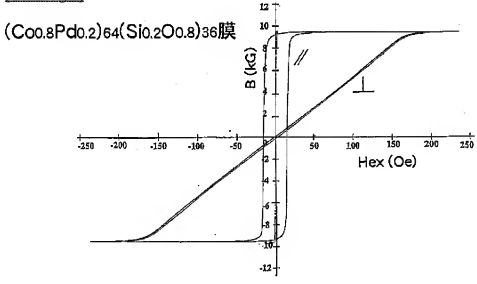
[Drawing 6]



[Drawing 4]



[Drawing 5]



[Translation done.]